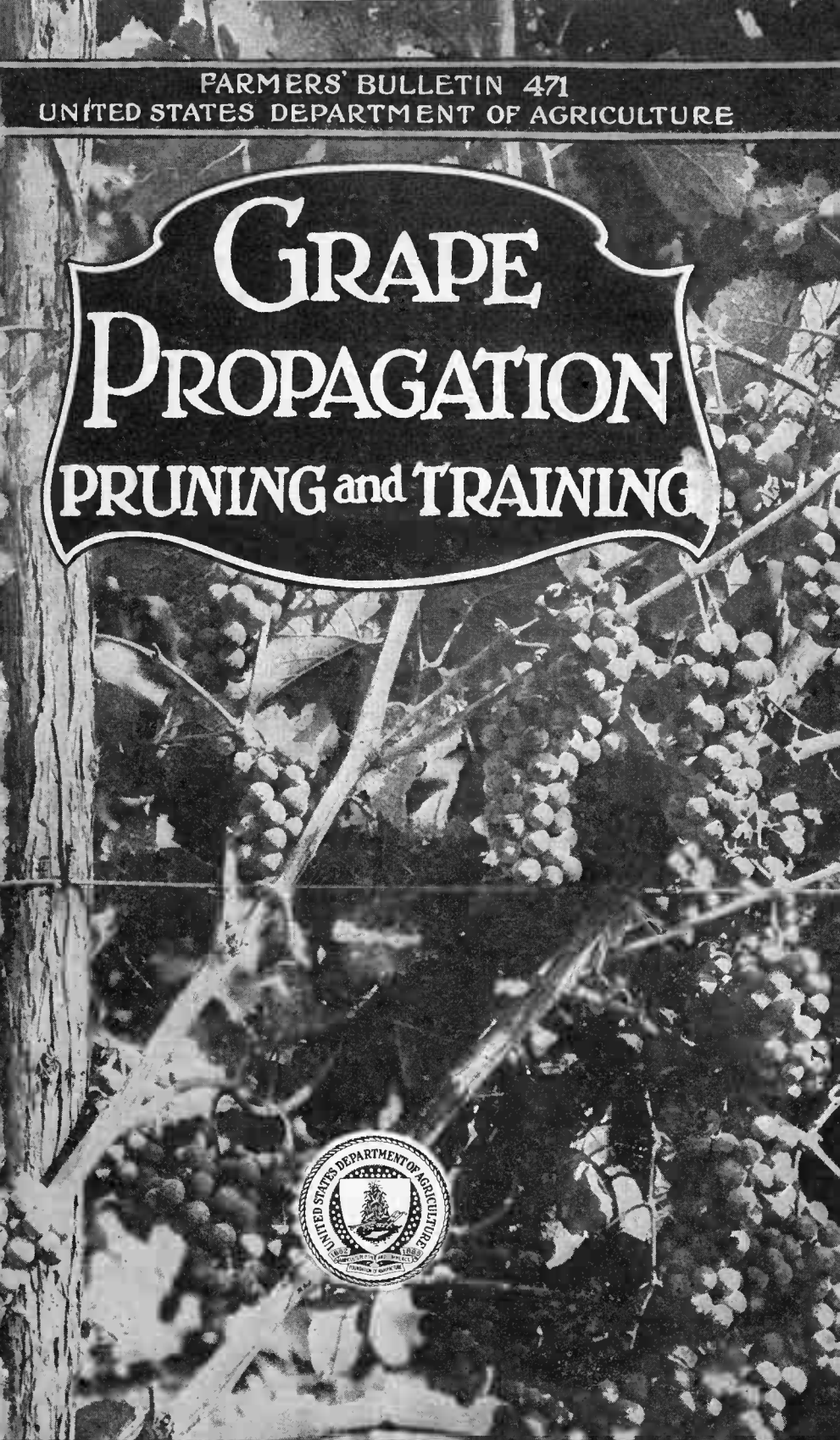
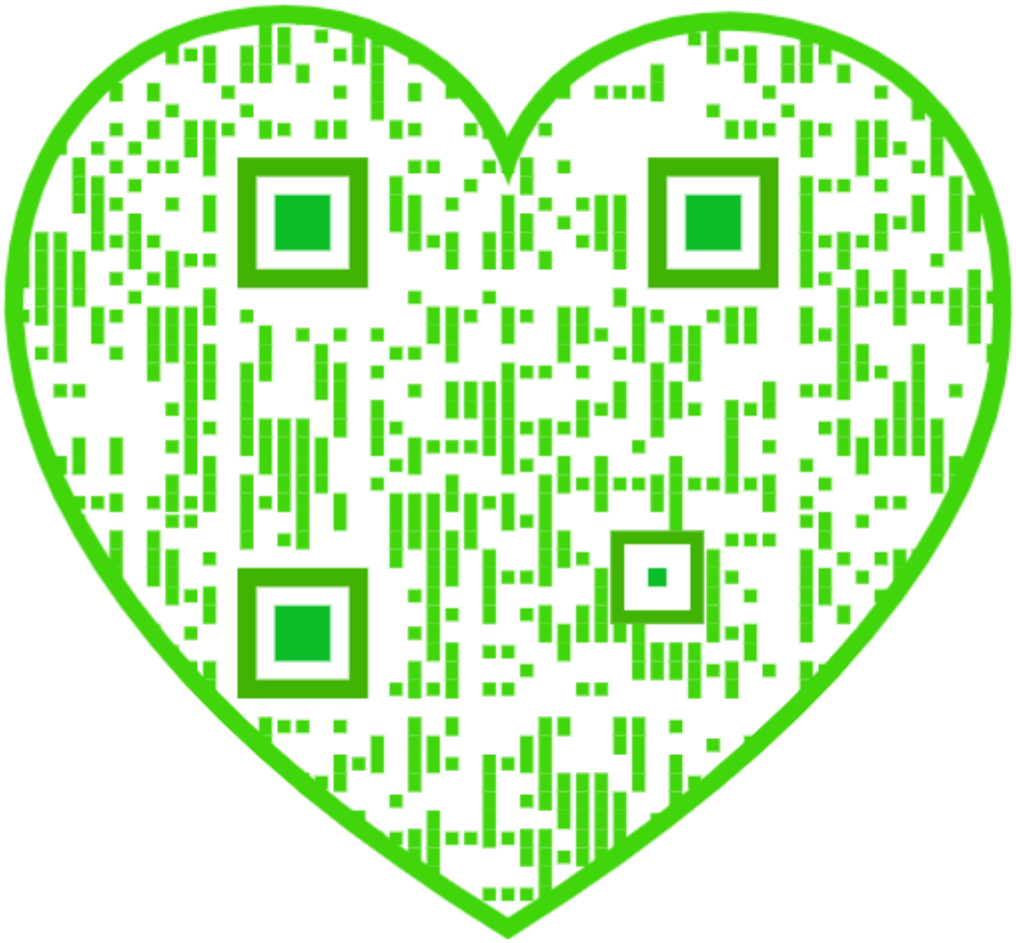
FARMERS' BULLETIN 471
UNITED STATES DEPARTMENT OF AGRICULTURE

GRAPE PROPAGATION PRUNING and TRAINING





SEEDLINGS, cuttings, layers, and grafts are four means of propagating the vine, but the first is only good for originating new varieties, and the young plants are seldom used even for grafting stock; so practically only three methods are available, each of which brings vines true to name. Descriptions of all these methods are found in this bulletin.

The principles, methods, and objects of pruning both the young and the bearing vines in winter and summer are presented in such a way as to enable the reader to grasp and practice them without further instruction.

The training systems followed in the principal grape regions as varied by the nature and habit of the different varieties are elaborated and illustrated, so that a selection may be intelligently made applicable to the development of a few vines on a city lot or through the varying conditions to an extensive vineyard.

The great and rapidly increasing number of persons interested in grape growing will find much of value in this pamphlet.

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

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GRAPE PROPAGATION, PRUNING, AND TRAINING.

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IMPORTANCE OF GRAPE CULTURE.

BY NATURE the grapevine is a great rambler. Forms of it are found in our woods striving to overtop the tallest trees, and single plants overspread large areas. Again, other forms are grown as mere bushes, 2 or 3 feet high, producing crops ranging from 1½ to 22 tons of fruit to the acre. No other fruit-bearing plant responds so generously to attention, adjusts itself to so many conditions, or is used for such a variety of purposes. For these reasons its culture has always kept pace with civilization. Grapes are often grown on soils too poor for other purposes.

FIG. 1.—An experiment vineyard of the Bureau of Plant Industry.

Native species of the grape are found in nearly all parts of the world, and no country is blessed with a greater number of them than our own. It is therefore reasonable to conclude that grapes can be successfully grown almost everywhere in this country, results with them depending largely upon the selection of varieties of the species suited to the respective conditions. (Fig. 1.)

PROPAGATION OF THE GRAPE.

SEEDLINGS.

In ordinary practice grapevines are propagated from seed, from cuttings, by layering, or by grafting. For originating new varieties, seedlings must of course be used. The individual seedlings differ so widely that they are seldom used by the intelligent planter even for grafting stock.

CUTTINGS.

Cuttings for propagation may be prepared at any time after the vines have become dormant. Other things being equal, and if they are afterwards well cared for, the sooner they are prepared after the vines have become dormant the better. The length of the cuttings may vary from 8 to 20 inches, depending on the climatic and other conditions of the locality in which they are to be planted. Usually, the hotter and drier the climate the longer the cuttings will need to be. They should always be made from young, well-matured wood, and preferably from medium-sized, short-jointed wood.

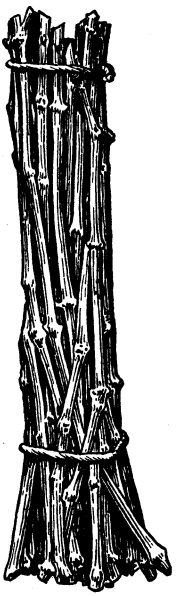

FIG. 2.—A bundle of grape cuttings.

To make cuttings, cut close below the lower bud, making the cut somewhat slanting (fig. 2), and leave about an inch of wood above the upper bud or eye. If a small piece of the old wood or a whorl of buds can be left to form the butt end of the cutting, so much the better. The cuttings should be tied in convenient-sized bundles, the butts being turned the same way. The bundles should then be heeled in or buried in trenches, butt ends up, and well covered with 3 to 6 inches of soil. (Fig. 6.) Inverting the bundles causes the butts to callus while the tops remain dormant, and the cuttings are ready to throw out rootlets as soon as planted; whereas, if the bundles are heeled in with the tops up the latter often start to grow before the roots to support them do.

In the spring, when the ground has become warm enough, plant the cuttings in soil made mellow by plowing and cultivating. The planting may be done in slanting trenches, 3 or 4 feet apart, which can be made with a plow. Deepen the trenches with a spade if necessary. Set the cuttings at such depth that only the upper buds will project above the ground and firm the soil well around them. The cuttings should be spaced 2 to 3 inches apart, the distance between them differing with the varieties, some rooting more readily than others. Keep the soil clean with hoe and cultivator, and stir often during the summer to keep it mellow and moist. Frequent stirring in many localities is better than irrigation.

LAYERS.

All varieties of the vine may be propagated by layers. The Rotundifolia vines are nearly always propagated in this manner,

but with other species layering is usually resorted to only with varieties which do not root readily from cuttings. In layering choose canes of the last season's growth, preferably those that start near the base of the vine. (Fig. 3.)

It is well, the summer before, to leave on the vine for this purpose some shoots starting close above ground and allow them to grow as long as possible. In pruning these canes all the well-developed buds are left. The ground is made mellow, a trench about 2 inches deep is drawn from the vine with the hoe, and the cane is bent down and fastened in it. Each bud on the cane will usually produce a shoot, which by this process is made to grow upward. When these shoots are well started the trench should be filled with soil. Each of the shoots then takes root at its base. To assist the roots in starting, a slight incision should be made in the cane opposite each shoot. The plants are taken up in the fall or winter, being divided by severing the original cane behind each shoot, which, having its own system of roots, becomes a new vine. (Fig. 3.) Canes may be layered either in the fall or in the spring.

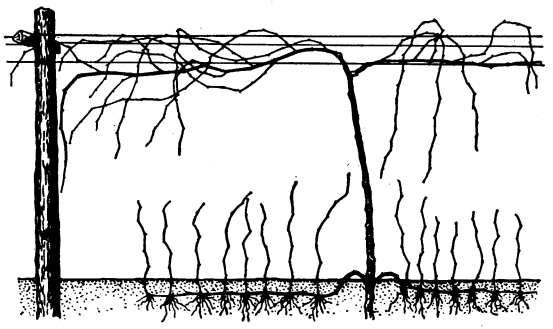

FIG. 3.—A vine with two canes layered, showing the method of propagation by layers.

GRAFTING.

There are many so-called methods of grafting. The following descriptions include only those most generally used. Bench, nursery, and vineyard grafting are resorted to in general vineyard practice. The mechanical operations performed are similar and the underlying principles are the same, the essential difference being, as the names imply, the place where the work is done.

Bench grafting is done on benches or tables, usually indoors during winter. Cuttings of resistant varieties that root easily or good, young, rooted plants are usually bench grafted.

The grafting of vines growing in the nursery is called nursery grafting. This form of propagation is usually resorted to with varieties resistant to phylloxera that do not grow readily from cuttings. Rooted cuttings of other varieties are grafted in the nursery and the resulting vines planted in the vineyard.

In vineyard grafting the vines growing where they are to remain are grafted.

Some of the important practical advantages of grafting are: (1) Changing worthless vines into valuable ones; (2) insuring non-resistant varieties against phylloxera by grafting them on resistant stocks; (3) obtaining quickly plenty of wood for propagating purposes by grafting new or scarce varieties on strong vines; and (4) producing resistant vineyards by grafting valuable resistants or direct producers on roots of growing vines and then allowing the scions to make roots of their own.

The selection and proper keeping of the scions for grafting are very important. Medium-sized, short-jointed, firm, well-ripened wood should be selected. Do not allow the scions to dry out, but keep them dormant until used by covering completely with fairly dry sand in a cool, dry cellar.

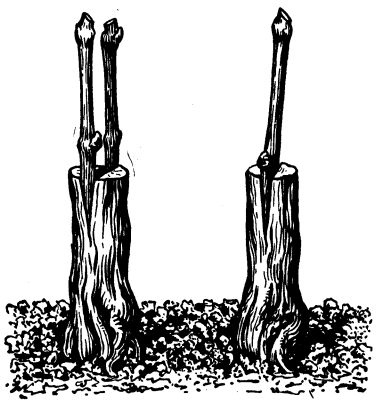

FIG. 4.—Vines grafted according to the cleft-graft method: At the left with two scions; at the right with one scion.

In all grafting a joining of the inner bark of the stock and scion must be accomplished. This bark is thicker on large than on small stocks; hence it is usually thicker on the stock than on the scion. The union, especially in vineyard grafting, needs to be closely observed when the scions are inserted. In bench grafting, scions and stocks of like diameter can be selected, making possible such perfect grafting that the inner barks join at almost every point, allowing their knitting to become easy and complete. (Fig. 5.)

In bench grafting, the visible and adventitious buds are cut out of the cuttings used as stocks so as to prevent as much as possible the sprouting of suckers from the stocks after they are planted.

In vineyard grafting, many operators, a month or so before grafting, cut off the stem of the vine an inch or two above where it is to be grafted so that the stock may bleed profusely. Water sprouts that otherwise would appear are thus to a great extent eliminated.

In cleft grafting, the vines are cut off at a smooth place near and preferably a little above the surface of the ground, unless it is desired to have the grafts establish themselves on their own roots, as it makes the removal of water sprouts and roots starting from the scion much easier and lessens the danger of injuring the scion before it is thoroughly knitted to the stock. (Fig. 4.)

In bench grafting, a smooth surface for grafting is selected above a node on the stock. The node keeps the stock from splitting below it during the grafting process. After cutting off the stock, whether a vine or a cutting, split it longitudinally with a sharp knife or shears, or if a heavy vine with a chisel. In cleft-grafting stocks not more than an inch in diameter the shears can be used in making both the horizontal and the longitudinal cuts. (Fig. 4.) To prevent the bruising of the bark in cutting, keep the blade of the shears on the side where the scion is to be inserted. To prepare the scion, cut with a sharp knife a simple wedge, beginning at or slightly below a bud and making a long sloping cut toward the middle and a similar one on the opposite side. Scions of two eyes are preferable. To insert, open the cleft and push the scion in firmly until the bud is just above the upper end of the stock, taking care that the inner barks of stock and scion fit closely. When large vines are grafted it may require a metal wedge to open the cleft. In large vines two scions, one on each side, are frequently used.

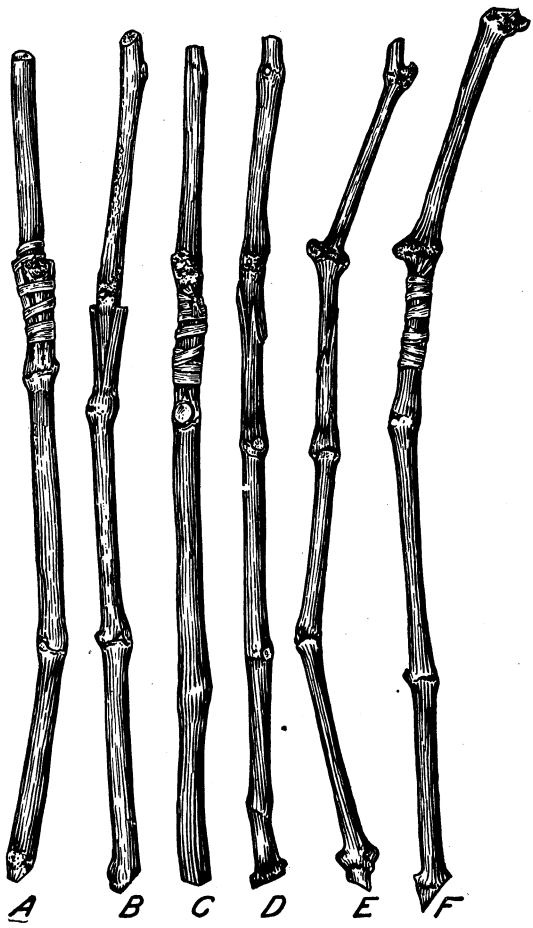

FIG. 5.—Bench-grafted cuttings of grapevines, showing three methods of grafting: *A, C, F,* Grafts tied with raffia; *B,* bench cleft graft; *D,* bench whip graft; *E,* English cleft, split, or whip graft.

Another favorite method with small stocks, especially in bench grafting when the diameter of the stock is the same or very little greater than that of the scion, is the English cleft, split, or whip graft. (Fig. 5, *E.*) By this method a sloping transverse cut is

made upward on the stock and a split downward from the middle of the cut. In the scion just the reverse but a like split and cut are made. Then the upper wedge made in the scion is pushed into the split of the stock in such a way that the inner barks join and fit closely.

When grafting is done near the ground on stocks strong enough to hold the scions firmly no tying is necessary; otherwise they should be tied with raffia, as shown in figure 5, *A*, *C*, and *F*. In either case a stake should be driven at the side of the graft to protect it and to provide a support for the young shoots. It is good practice to press a little moist soil over the cut around the junction of the graft and to cover the scion completely with fine dirt, hilling it up sufficiently to protect it from drying out.

When vines grafted above ground are not covered with dirt the entire cuts should be waxed to exclude the air. The grafts should be examined frequently and the suckers removed, and the roots starting from scions that have been grafted on resistant stocks should be cut off.

Bench grafts are also tied with raffia. (Fig. 5.) They may be planted out directly, but bench-grafted cuttings are usually stored or are heeled in upside down in damp, not wet, river sand, moss, or other suitable material, to allow them to callus before planting. (Fig. 6.)

SOIL AND LOCATION.

The soil and location best suited, the preparation of the soil, the laying out of and cost per acre of establishing a vineyard, and the cultivation and fertilization necessary for obtaining the best results are not presented here, as they vary decidedly with differing conditions of soil, climate, etc., and need to be dealt with in a special treatise on the subject.

The uses and manipulation of the vine for various purposes and the insect and fungous enemies of the grape, with methods of combating them, are discussed in other publications.[1]

DESCRIPTION OF THE PARTS OF A VINE.

A clear understanding of the names of the different parts of a vine is necessary before the subject of grape training is considered.

[1] Farmers' Bulletins: No. 27, Important Insecticides; Directions for Their Preparation and Use. No. 175, Home Manufacture and Use of Unfermented Grape Juice. No. 243, Fungicides and Their Use in Preventing Diseases of Fruits. No. 284, Insect and Fungous Enemies of the Grape East of the Rocky Mountains. Yearbook Papers: No. 281, Grape, Raisin, and Wine Production in the United States. No. 354, Some Uses of the Grapevine and Its Fruit. These publications are issued for free distribution and may be obtained upon application to the Secretary of Agriculture or any Member of Congress.

Figure 7 illustrates a vine, the different parts of which are shown by letters, as follows: *T*, trunk, the stem or main body of the vine; *B*, branches, which are of mature wood, being several years old; *A*, arms or ramifications of the branches, usually of wood two or more years old; *C*, canes, called shoots when green and canes when mature; *S*, suckers, the shoots which start below the ground from the main body; *WS*, water sprouts, the shoots which start above the ground from wood older than one year; *L*, laterals, the secondary shoots of a cane.

FIG. 6.—Grafts or cuttings ready for heeling in.

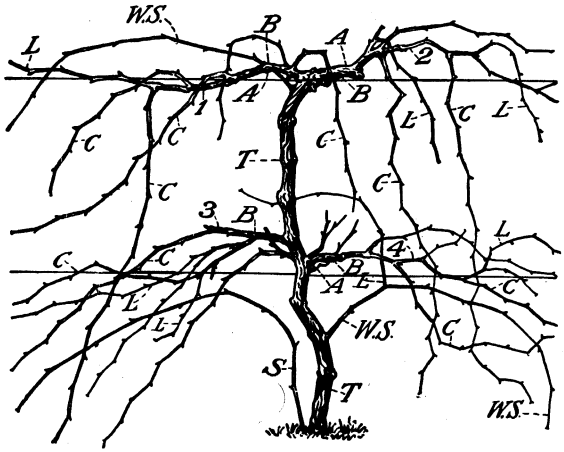

FIG. 7.—Diagram of a grapevine, showing the different parts and illustrating the four-cane system of training: *A*, Arms or ramifications of the branches, usually of wood two or more years old; *B*, branches which are of mature wood, being several years old; *C*, canes, called shoots when green and canes when mature; *L*, laterals, the secondary shoots of a cane; *S*, suckers, the shoots starting below the ground from the main body; *T*, trunk, the stem or main body of the vine; *W. S.*, water sprouts, the shoots which start above the ground from wood older than one year; *1*, *2*, *3*, *4*, 2-year old arms.

The basal eye or bud, which is not reckoned in counting the eyes on a spur, is near the base of the cane. When more than four eyes of a cane are left in pruning it is generally called a fruiting cane.

Water sprouts and suckers do not ordinarily produce bearing shoots.

Below the basal bud on each cane are one or more dormant buds, which grow and produce sterile canes only when too few eyes are left in pruning or when the eyes have been destroyed. At the base of each eye on a cane there are two dormant buds. Sometimes one of

these grows the season it is formed, making a lateral from which secondary laterals also may grow.

The first and secondary laterals bear the so-called second and third crops of grapes.

CARE AND TRAINING OF YOUNG VINES.

The treatment given vines during the first years of their growth largely determines the profit and pleasure to be derived from them. If improperly cared for during this period satisfactory returns are not obtained afterwards.

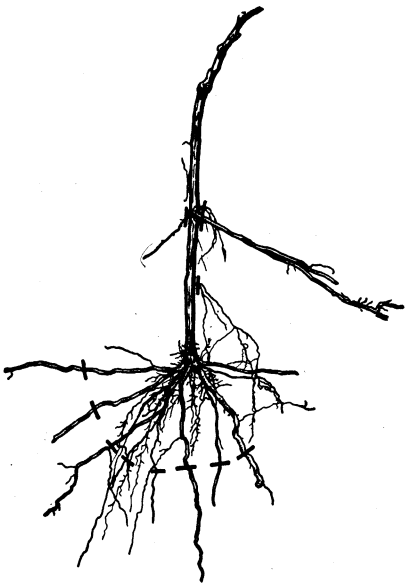

FIG. 8.—A grapevine showing the method of pruning roots ready for planting.

PLANTING CUTTINGS OR ROOTED VINES.

If cuttings (fig. 2) are planted and the supply is sufficient, two in each place increases the chances of getting a full stand. Should both cuttings grow, one of them can easily be pulled up without injuring the other. To protect the cuttings from drying out, plant them so that the top bud projects only a trifle above the ground.

FIG. 9.—A vine pruned at the end of the first year.

If rooted vines, either plain or grafted, are used, the roots should be cut back to 3 to 4 inches, depending on their vigor. Only one cane of the top should be left, and this should be cut back to two or three good buds. (Fig. 8.) If grafts are used, all scion roots and all suckers should be carefully removed.

During the first year after planting, no pruning or training is usually given, although it is, perhaps, a good plan with vigorous plants, especially if the season is propitious, to rub off all except the straightest and strongest of the young shoots that start. (Fig. 9.) The following winter the vines should be pruned and staked before they start to grow, the size of the stake used depending on the method of training adopted. In ordinary stool or spur pruning, or

where the vines are to be trellised or arbored afterwards, a stake 1½ to 2 inches square should be used, long enough so that after being driven 1½ feet into the ground it will reach 1 or 2 inches above where the vine tied to it is to be headed. If the vines are to be pruned to canes and the latter tied to stakes, it will be necessary to use stakes 2 inches square and 5 to 6 feet long. (Fig. 11.) When Rotundifolia varieties are to be grown on overhead arbors, posts projecting about 7 feet above the ground should be planted on the side of each vine opposite the prevailing wind. (Figs. 10 and 11.)

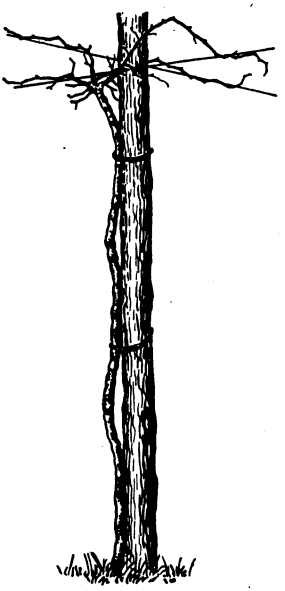

FIG. 10.—A Rotundifolia grapevine trained to a post.

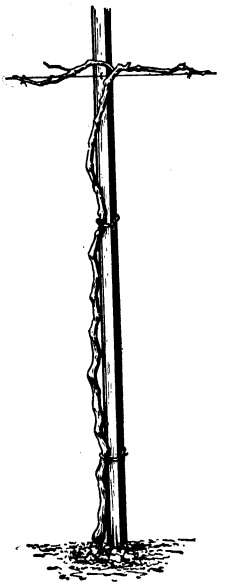

FIG. 11.—A grapevine trained to a stake.

FIRST PRUNING AFTER PLANTING.

The first pruning after planting may be done at any time during the winter when the vines are dormant and not frozen. The extent of the pruning will depend on the growth made. If the growth has been small, all the canes except the strongest should be removed, and this one cut back to two eyes. (Fig. 9.) If a strong growth has been made and there is one straight well-ripened cane, all other growth should be removed and this cane cut back to the height at which it is intended to head the vine. The cane should be tied securely and, as it is to become and remain the trunk or main body of the vine, should be kept as nearly erect and straight as possible. (Fig. 12.)

SUMMER PRUNING.

Where the vine was cut back to two buds only one should be allowed to grow. All other young shoots should be removed (fig. 12), preferably when quite young and not more than 3 or 4 inches long. This concentrates all the force and growth of the plant into the cane, which is to become the trunk of the vine. The shoot

left to grow must be kept carefully tied to the stake to cause it to grow erect and also to protect it from being broken by the wind or other agency. When a shoot has grown to a foot above where it is intended to head it should be topped slightly above where the head is to be, causing laterals to grow where they are desired. Only such shoots should be allowed to grow as are needed for shaping the vine for the following season. (Fig. 13.) All suckers should be promptly removed.

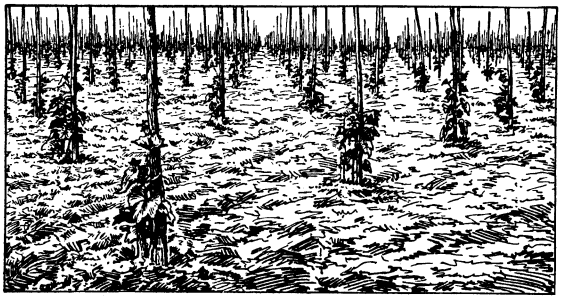

FIG. 12.—Vines growing in a vineyard the first year, showing single shoots tied to stakes.

WINTER PRUNING.

By the third year all vines should have erect, straight stems with two or more canes growing from the principal part, out of which the head or crown is to be formed and from which the growth of the vine is to be renewed from year to year. (Fig. 13.)

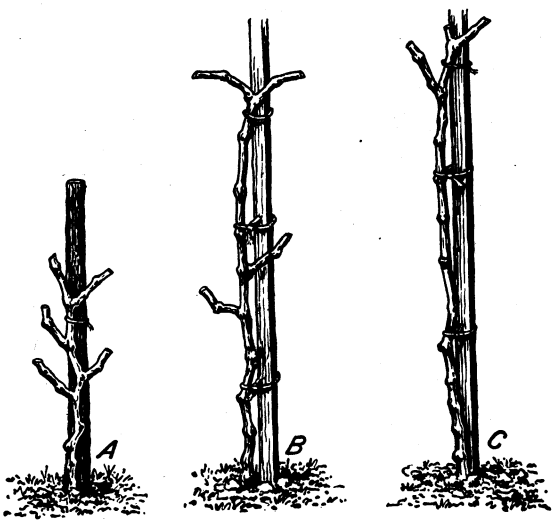

FIG. 13.—Vines headed back for different systems of training: *A*, The spur and fan systems; *B*, the four-arm renewal system; *C* the two-arm Kniffin, Munson, umbrella, and overhead systems.

The vine, when permitted to do so, bears its fruit on shoots from the last year's wood growth; therefore, the cardinal point underlying all correct pruning, be the method of training what it may, is first to grow and shape or adjust the main body or permanent part of the vine to the method of training desired. After this has been done the growth on this, the fruit-bearing part of the plant, should be so pruned that it will be renewed from year to year, never allowing the

plant to overbear but making it bear to its full capacity. If this is done the body of the plant gradually becomes stronger and its fruiting capacity increases correspondingly, no wasteful plant growth is allowed at the expense of fruitage, and the vines are easily kept clear of insects and fungous diseases. The manner of renewing the growth on the body of the vine so as to leave the body permanent is illustrated in figures 7 and 14, which show the same vine before and after pruning.

In figure 7 the 2-year-old arms *1*, *2*, *3*, and *4*, which grew during the previous summer, were the only ones allowed to remain of all the canes when the vine was pruned in the winter. The canes shown grew from these and bore fruit the next summer. When pruned the following winter, as seen in figure 14, only the canes *a*, *b*, *c*, and *d* were left, and these were tied to the wire in the same manner as the arms *1*, *2*, *3*, and *4* of the season before. (Fig. 7.) The spurs shown (fig. 14, *Sp.*) are canes cut back to one to four eyes for the purpose of starting new canes to be left the following year. It took 10 cuts to prune the entire vine.

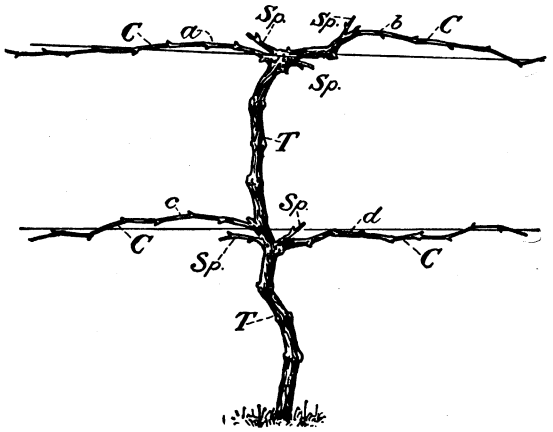

FIG. 14.—A vine pruned according to the four-cane Kniffin system: *C*, Canes, called shoots when green and canes when mature; *Sp*, spurs, canes cut back to one to four eyes; *T*, trunk, the stem or main body of the vine; *a*, *b*, *c*, *d*, arms succeeding those shown at their 2-year old stage in figure 7 at *1*, *2*, *3*, *4*.

Not only do different countries have different methods of pruning and training, but methods often vary in the several districts of the same country. The inherent peculiarities of the varieties themselves often require special methods to obtain the best results. No attempt will be made to describe methods other than those that appear most applicable and have proved most satisfactory for the grape species grown in various parts of the United States.

THE PRUNING OF BEARING VINES.

PRINCIPLES CONSIDERED IN PRUNING.

To prune intelligently, the age, size, and condition of the plant, the location, climate, soil, and other features of its environment, and the principles governing its life must be considered.

A statement of some of the more important of these life principles follows: The sap flows with greatest force to the outer extremities; the more upright a branch is, the more sap flows into it; the sap when abundant and active produces wood; the more abundant the flow of the sap, the larger and later the fruit; the ascending sap grows richer the farther it flows; checking the flow of the sap makes the plant bear earlier and produces more and richer fruit. The vine usually bears its fruit on new shoots growing from the wood of the previous year. The time for pruning is in winter, when the vines are dormant. They should not be cut when frozen or while the sap is flowing rapidly. Summer pruning is practiced on the young growth to regulate the quantity of fruit and the shape of the plant.

OBJECTS OF PRUNING.

In pruning, one or more of the following objects are usually accomplished: Parts of plants removed, renewed, promoted, or retarded; wounded and diseased plants cured; the shapes and habits of plants modified; the size and quantity of the fruit increased or diminished; the quality of the fruit improved; the fruit made to ripen earlier or later; a regular succession of fruit secured; and the spraying, training, cultivation, and gathering of the fruit facilitated.

METHODS USED IN PRUNING.

There are various ways in which the objects of pruning are accomplished. For instance, the growth and health of a plant are promoted and the size of the fruit is increased (1) by removing all the diseased parts and suckers; (2) by shortening extended shoots, side shoots, and laterals; (3) by putting upright the part whose rapid growth is desired; and (4) by removing the fruit buds or fruit. The plant is retarded in growth and made to bear earlier and richer fruit by shortening the leading shoots and leaving the fruit-bearing wood and by bending down the branches and ring-pruning them. The healing of wounded and diseased plants is promoted by removing the injured parts and dressing the wound. The head of a plant is renewed by cutting off the branches above; the head is made to grow thicker by cutting back the outer branches and to grow thinner by amputating all canes on which there is too much growth.

There are so many species of grapes, each having peculiarities of its own and therefore responding most readily to certain cultural methods to which it is best adapted, that the pruning, training, and growing of vines, which otherwise may appear quite simple, become complicated operations in which comparatively few people become expert, and vineyards in which serious mistakes are not made are rare.

TRAINING AND TRAINING SYSTEMS.

Around city homes where there is room for only a few vines, they are often trained on porches, fences, outbuildings, trees, etc. Where there is sufficient space an arbor like that shown in figure 15 is a

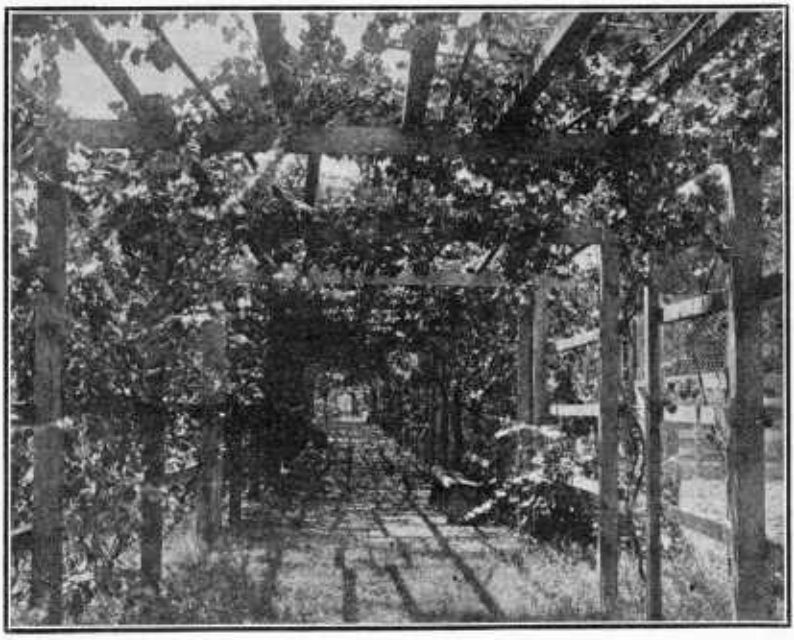

FIG. 15.—A grape arbor.

good and attractive support, making the vine furnish a shady bower or walk as well as fruit. In vineyard practice some growers use only a stake or post on which to train each vine. (Fig. 11.)

THE TRELLIS.

A support very generally used on which to train the vine consists of substantial posts of durable timber planted at regular intervals, the distance apart varying with the different grape varieties and the distances between the plants. (Fig. 16.) To the posts sometimes only two, but generally three, strands of No. 10 or No. 12 wire are fastened, the first, second, and third wires being 24, 40, and 56 inches, respectively, from the ground. The end posts of the rows should be firmly braced. The two most common methods of bracing

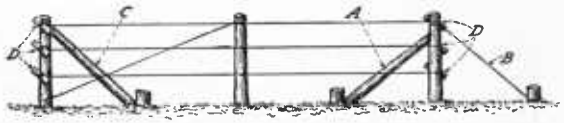

FIG. 16.—Diagram of an ordinary trellis, showing the braces (*A, B, C*) and devices (*D*) used for tightening the wires.

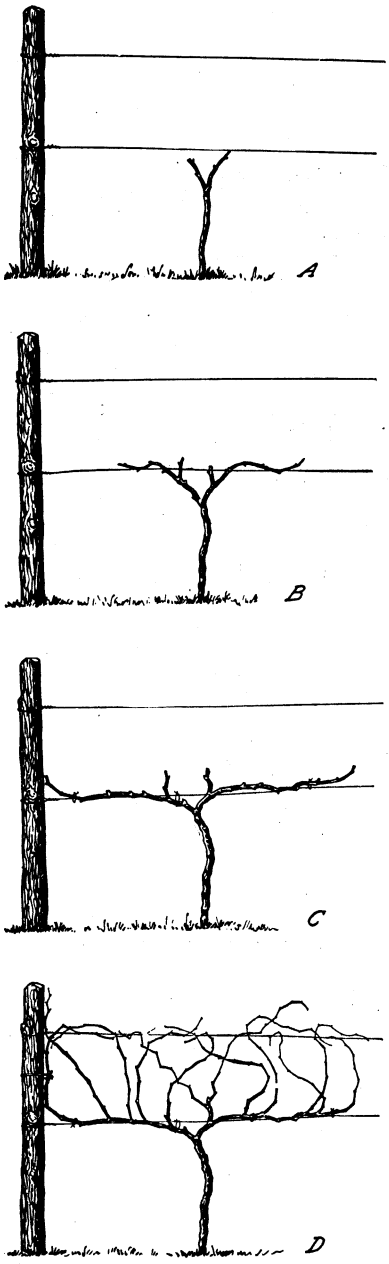

FIG. 17.—A pruned and an unpruned vine at different ages, showing the method of pruning by the renewal system: *A*, Second year; *B*, third year; *C*, fourth year; *D*, an unpruned vine in its fourth year.

are shown in figure 16, *A* and *B*. Another post-bracing method often used is shown at *C* in figure 16. As wire contracts in cold and expands in warm weather, the trellis wire should not be stapled to the end posts, but should be fastened to them by some device like a simple reel, as shown at *D* in figure 16. Some use a clamp pulley and a rope for tightening the wire and then wind the slack part two or three times around the end post to fasten it.

THE HIGH-RENEWAL OR UPRIGHT SYSTEM.

In the high-renewal or upright system of training, all the season's growth is cut off each year except the head of the vine, which is cut back, leaving a cane and a spur on each side, and the canes are tied to the lower wire on the trellis. The length of the canes and the number of the eyes left on them will vary with the variety and size of the vine. The fruiting shoots growing from the canes are trained upright and fastened to the wire overhead. Figure 17, *A*, shows a vine pruned according to this system at the end of the second and figure 17, *B*, at the end of the third year. Figure 17, *D* and *C*, shows the same vine a year later, before and after pruning. This system is the one most generally practiced in the training of American grape varieties. Vines trained by this system can be easily laid down and covered in winter in the extreme northern sections.

A small amount of wood is left in pruning healthy vines and a good quality of fruit is obtained.

THE HORIZONTAL-ARM SPUR SYSTEM.

In the horizontal-arm spur system two horizontal arms, one on each side, are grown from the body of the vine at the lower wire of the trellis and tied to this wire. These arms remain, but the canes on them are cut back every year to spurs of two fruitful buds each. The fruit-bearing shoots growing from these are tied to the wires overhead, the number of spurs left depending on the variety and size of the vine. New spurs to replace those becoming weak or out of shape are grown from new shoots starting from the horizontal arm.

In this system the vines are pruned and trained the same as for the high-renewal system, up to the end of the fourth year. Sometimes the horizontal arms are also renewed. Figure 17, *D*, represents an unpruned vine. Figure 18 represents the same vine pruned according to this system.

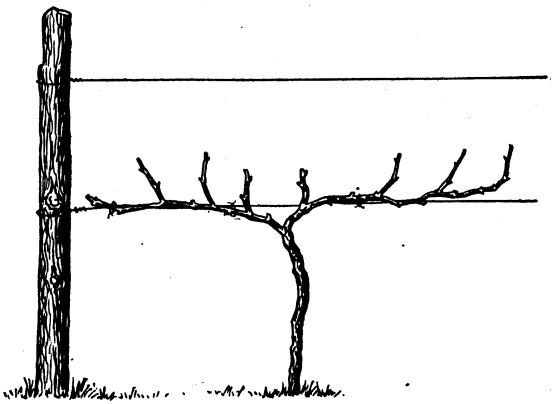

FIG. 18.—A vine in its fourth year pruned according to the horizontal-arm spur renewal system.

This system was at one time extensively practiced in the Chautauqua grape belt on Lake Erie. With it more fruit is obtained from some varieties than by the preceding method, which results in too much wood growth; otherwise it is not as good. More old wood is left and the pruning is more tedious and expensive than with the high-renewal system.

THE HORIZONTAL BLOCK SYSTEM.

A system combining some of the points of each of the preceding ones is the horizontal block system. In this the vines are manipulated as with the preceding systems and pruned in the same way for the first four years, after which the unpruned vine is pruned as shown in figure 19. As practiced in the same localities this system appears to be a combination of the high-renewal and the horizontal-arm spur systems.

THE FAN SYSTEM.

In the fan system the vine growth, which is trained to an upright trellis, is annually renewed to within a short distance from the ground. The vines are cut back usually to four canes and as many spurs each year; the canes are spread out and tied to the trellis, giving the vine the shape of a fan. Figure 20, *A* and *C*, shows an unpruned vine in the third and fourth years. Figure 20, *B*, shows the same vine pruned the fourth year for this system.

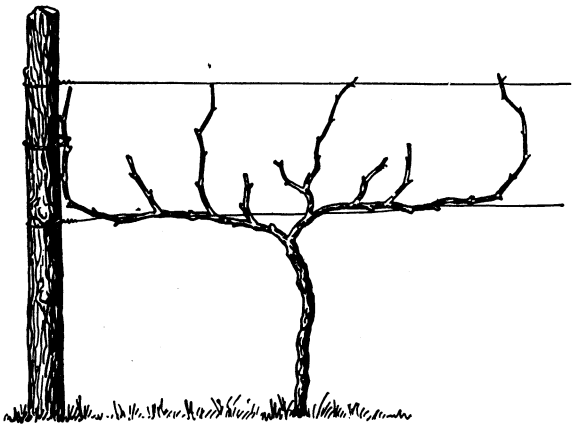

FIG. 19.—A vine in its fourth year pruned according to the block system.

The advantages claimed by the advocates of this system are (1) that most of the old wood is dispensed with each year, (2) that the vines can be easily laid down and covered in winter when needful in the extreme northern sections, and (3) that if after pruning the canes are tied and spread fan shaped on

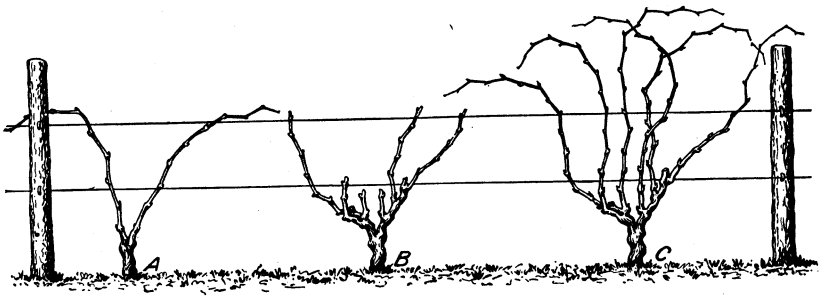

FIG. 20.—A vine at different ages, showing the method of training by the fan system: *A*, An unpruned vine in its third year; *B*, a pruned vine in its fourth year; *C*, an unpruned vine in its fourth year.

the trellis, as they should be, the young upright-growing shoots fasten themselves by their tendrils and need practically no tying. This system has the disadvantage of bearing the fruit too low and is not now so generally in use as formerly.

THE HUDSON HORIZONTAL SYSTEM.

The Hudson horizontal system, extensively practiced, as its name implies, along the Hudson River, uses an ordinary two-wire trellis. A strong stake reaching to the top wire of the trellis is driven behind each vine. Four perpendicular slats which do not touch the ground are fastened to the trellis, two on each side of the vine and 12 to 15 inches apart. Woven-wire fence could be substituted for the slats. The vine is annually renewed back to the trunk, which is about a foot high, and a single cane and spur are left at each pruning, the cane long enough so that when tied it reaches to the top of the stake. About six bearing shoots left to grow on each side of this cane are fastened horizontally to the slats. The clusters hang free from the shoots. When the shoots become too long they should be summer pruned. From the spur left on the trunk the cane is grown erect and tied to the stake, to become the fruiting cane to be left the next

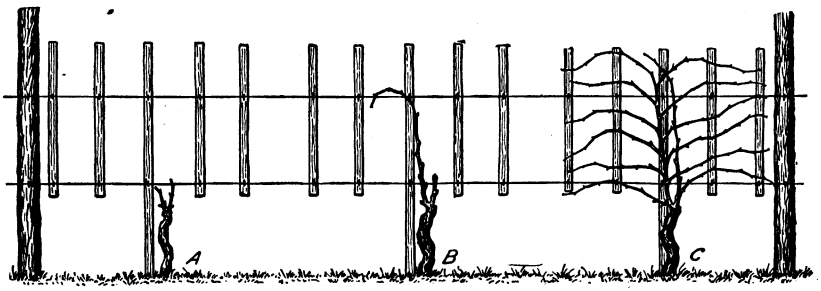

FIG. 21.—A vine at different ages, showing the method of training by the Hudson horizontal system: *A*, A pruned vine in its third year; *B*, a pruned vine in its fourth year; *C*, an unpruned vine in its fourth year.

year. Figure 21, *A*, shows a vine at the end of the third year pruned according to this system. Figure 21, *C* and *B*, shows the same vine before and after pruning a year later.

The advocates of this system claim for it a more uniform distribution of the young shoots and say that the fruit hangs well supported and protected.

THE FOUR-CANE KNIFFIN SYSTEM.

On the trunk of the vine at the lower wire of a two-wire trellis, about 30 inches from the ground, two canes and two spurs are left of last year's growth, and two more canes and spurs are left at the top wire, about 56 inches from the ground. These canes, which are tied to the wire on each side of the vine, produce fruiting shoots which are allowed to hang down or droop as seen in figure 7. The same vine as it appears after pruning at the end of the fourth year when trained according to this four-cane Kniffin system is shown in

figure 14. This system is named after William Kniffin, who first employed it. It has been extensively used along the Hudson River and elsewhere, and is said to be especially adapted to strong-growing varieties. Vines trained by this system are easily and quickly pruned and require only a limited amount of labor in the growing season.

THE UMBRELLA OR TWO-CANE KNIFFIN SYSTEM.

A system very generally used in the training of American vines, known as the umbrella or two-cane Kniffin system, differs from the foregoing in that no canes or spurs are left at the lower wire, the trunk of the vine extending directly to the top wire, where the growth is annually cut back to two canes and two spurs, one on each side, which are fastened to the top wire. It is best to tie the trunk to both the upper and lower wires to prevent violent whipping of the hanging shoots. Some growers dispense with the lower wire. Figure 22, *A* and *B*, shows a vine, trained according to this system, before and after pruning at the end of the fourth year.

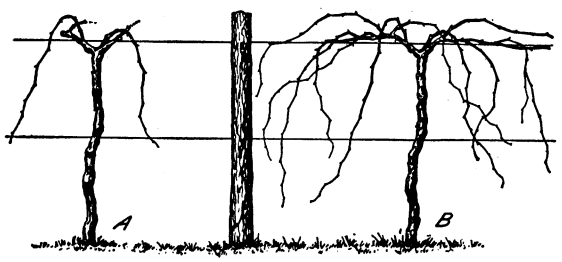

FIG. 22.—A pruned vine (*A*) and an unpruned vine (*B*), showing the method of training by the umbrella system.

This system is really an improvement on the four-cane Kniffin system. The absence of the two lower canes insures a good upright trunk, and the renewal of the fruit-bearing wood to one head makes the vine more easily pruned, leaves less old wood, and results in cleaner and better-ventilated vines.

THE MUNSON SYSTEM.

The Munson system derives its name from its originator, Prof. T. V. Munson, of Denison, Tex. As first practiced by him, use was made of two rows of light posts or stakes, the posts being driven opposite each other, their tops being about 18 to 20 inches apart. Wires were stretched along the tops of the posts in each row, with a third wire somewhat lower and midway between them upon cross wires.

Munson now uses single posts. Across the top of each post a crossbar of wood is fastened. The outer wires of the trellis are fastened to the outer ends of the crossbar, and the inner wire is fastened to the post the desired distance lower down. The writer secures essentially the same results in practice by using durable posts suffi-

ciently heavy to allow pieces of 2 by 4 inch joist, 2 feet long, to be firmly spiked to them either at the side or on top, when sawed off at the right height for the purpose. The outer wires are stretched on the cross joist, and the lower wire is either stapled against or run through the posts at the desired distance below, as shown in figure 23, *B*. Four to 4½ feet above the ground is a good height for the lower wires for most varieties.

By this system a single main trunk for each vine is grown and tied to the lower wire. In pruning this trunk two canes and two spurs are annually left. The canes running to the right and to the left are securely tied to the lower wire. The outer wires are for the sole purpose of supporting the growing shoots, which naturally develop from the canes and gradually droop toward the ground. Figure 23, *A* and *B*, shows the vines pruned and unpruned, trained after the modified Munson system. The writer considers this the best all-round system of training for use in localities where rains and storms occur during the growing season. It protects the fruit and places it in the most advantageous surroundings for the best results. It makes practicable and facilitates spraying for fungous diseases and insect pests and, after the original outlay for the trellis has been incurred, lessens the cost of all operations and makes them easy and pleasant.

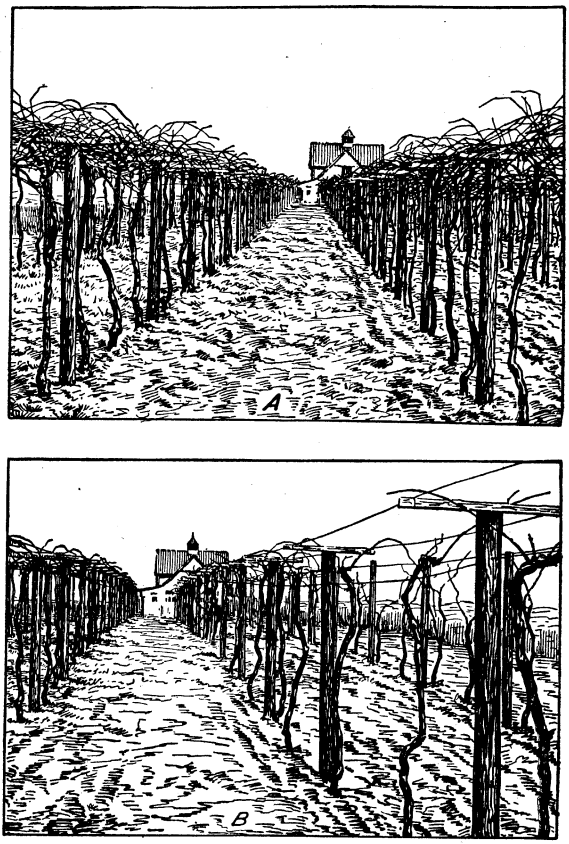

FIG. 23.—Unpruned vines (*A*) and pruned vines (*B*), showing the method of training by the modified Munson system.

THE OVERHEAD CAYWOOD SYSTEM.

In the overhead system, which has been used to some extent in New York, the vines are carried upon a canopy or overhead arbor 6 feet above the ground, consisting of three horizontal wires stretched at the same height. The center wire is fastened to posts which are placed at regular intervals, and the side wires are attached to 3-foot cross arms of wood fastened to the posts. The head of the vine is annually cut back to five canes and five spurs. The canes are fastened on the wires, two in one direction and three in the other, this division being alternated each year. Figure 24, *A* and *B*, shows vines pruned and unpruned, trained according to this system.

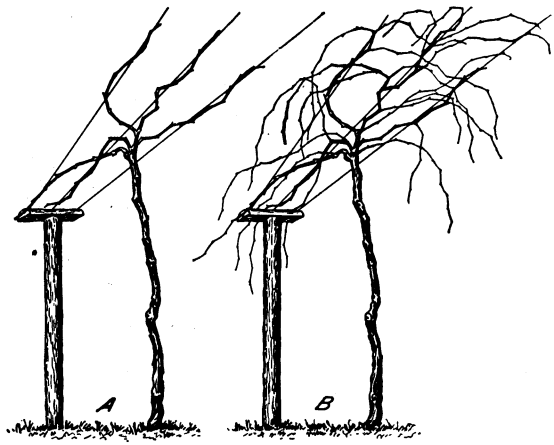

FIG. 24.—A pruned vine (*A*) and an unpruned vine (*B*), showing the method of training by the overhead Caywood system.

It has no advantages over the modified Munson system just described and to the writer appears inferior in every way.

THE CHITTENDEN SYSTEM.

The Chittenden system as employed in Michigan is similar to the overhead system, but the trellis is lower, not exceeding 4 or 5 feet.

THE MULTIPLE CROSS-WIRE SYSTEM, OR OVERHEAD ARBOR.

The multiple cross-wire system is used largely with the Rotundifolia varieties of the South, which are usually planted 10 by 20, 15 by 15, or 20 by 20 feet apart. In following this method a substantial, durable post reaching 7 feet above the ground is planted at each vine. Rows of well-braced posts, running parallel with and also at the ends of the rows of vines, are set at the boundaries of the vineyard. From the tops of these posts on the four sides of the vineyard a No. 10 galvanized wire is run along the tops of the inside posts down each row in both directions as a governor wire. No. 14 wires, 2 feet apart, are run parallel with the governor wires until in this manner the

entire area has been regularly covered. It has been the general custom to cause a single trunk to grow erect from the ground up alongside each inside post, keeping it tied thereto. When the vine has reached the top of the post it is pinched in or cut back so as to make it throw out shoots to grow and spread over the arbor. When this object is accomplished it is the general practice to do no more pruning, the growers asserting that the vines prune themselves. There is no reason, however, why the Rotundifolia varieties should not be pruned and the fruit-bearing tops regularly renewed. Some growers construct arbors entirely of wood, using slats instead of wires. (Fig. 25.)

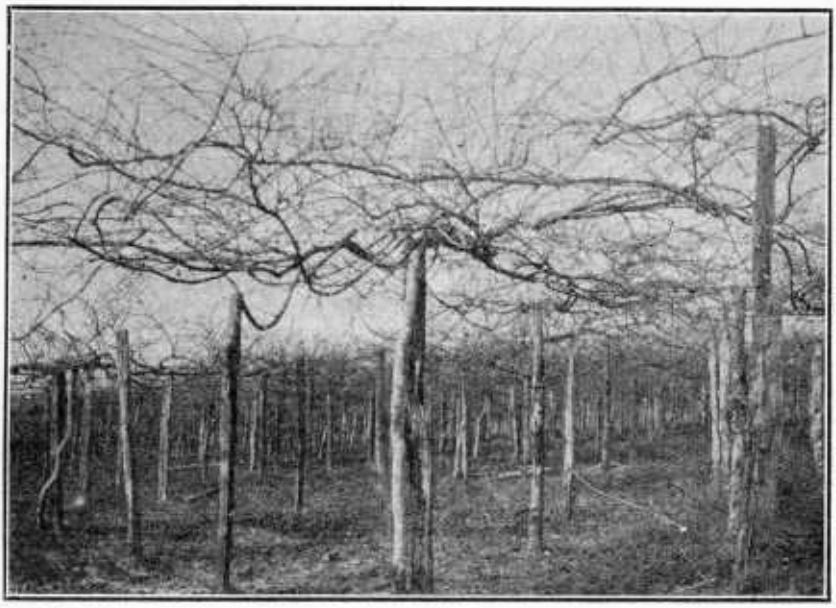

FIG. 25.—Vines trained by the multiple cross-wire system or overhead arbor.

From experiments as to the best methods of training Rotundifolia varieties, which the United States Department of Agriculture is conducting under the direction of the writer for the purpose of improving the quality of the fruit, getting better and more regular fruiting results, counteracting black-rot injury, etc., there is reason to believe it will soon be necessary to advocate the growing of Rotundifolia varieties on an upright trellis.

THE OVERHEAD TRELLIS OR PARRALES SYSTEM.

The overhead trellis or parrales system is used in Almeria in training the Ohanez and other Almerian varieties of grapes, large quantities of which shipped in cork dust reach our markets every year. The trellis used is practically the same as the overhead-wire trellis

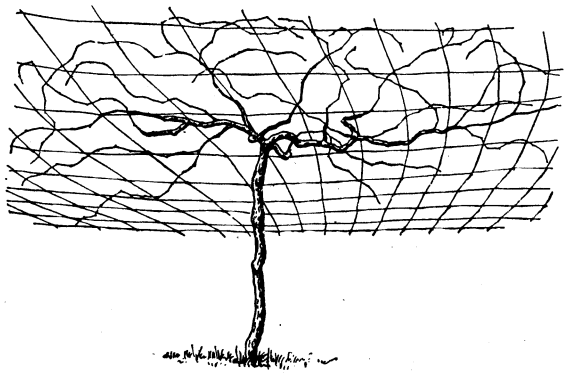

FIG. 26.—Parrales, showing the system of training and the arrangement of the wires.

just described as in use for the Rotundifolia varieties. The Almerian vines are planted about 15 by 15 feet apart and trained with a straight stem to a height of about 7 feet. From the top of this stem fruiting canes varying from 10 to 15 in number and from 1 to 6 feet in length, according to the strength of the vine, are run out in all directions. These canes are annually renewed as near back to the main stem as possible with canes grown from spurs left for this purpose. (Fig. 26.)

THE CROSS-WIRE SYSTEM.

The single cross-wire system is used in the vicinity of Marlboro, N. Y. In this system posts are set 8 feet apart each way and made to project 6½ feet above the ground, a single wire running on top from post to post in both directions. A single trunk vine is trained up each post, four canes being run from it at the top of the post and one cane is fastened to each of the radiating wires. These canes are renewed each year. Figure 27 illustrates a vine pruned after this system.

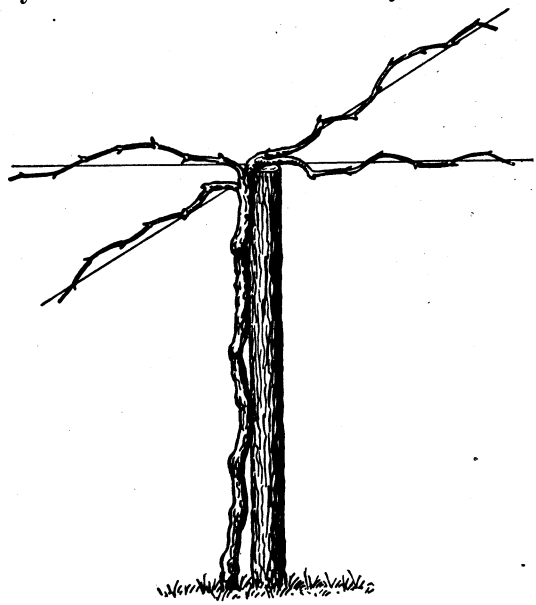

FIG. 27.—A pruned vine, showing the cross-wire system of training.

THE SPUR, STOOL, OR SHORT PRUNING SYSTEM.

The spur, stool, or short pruning system is the one so extensively used in California with the stockier growing varieties of Vinifera. It is the simplest and cheapest method of pruning and training vines. By this method the body of the vine is grown to the desired height, and shoots are permitted to grow from only the two uppermost buds. The two resulting canes are cut back in the winter to spurs of two eyes each. The following year these spurs are allowed to produce growth and the resulting canes are again cut back to spurs and all of them allowed to remain if the vine is strong enough. (Fig. 13, *A*.) Thus the vine under ordinary conditions at the beginning of the fifth year consists of a trunk from which spring four or five arms, on each of which a cane has been cut back to a spur, as shown in figure 28. When the vine is pruned the following winter all or nearly all the outer canes that have grown from the spurs are entirely removed. The spurs of the last season are cut off just outside the inner canes, which are cut back to spurs, the pruning each winter after this being to promote a regular system of spur renewal. As the vines become older and stronger and can stand more cropping, more spurs are left to increase the fruiting capacity of the plant. In course of time the arms of the respective spurs are renewed and entirely new arms and spurs are grown. The head of the vine should be kept well balanced and given a globular form, if possible. Some varieties on which the lower eyes are not sufficiently productive may be improved by increasing the length of the spurs and the number of eyes, leaving four or even five eyes to a spur according to the variety of vine.

FIG. 28.—A pruned vine in its fifth year, showing the method of training by the spur, stool, or short system.

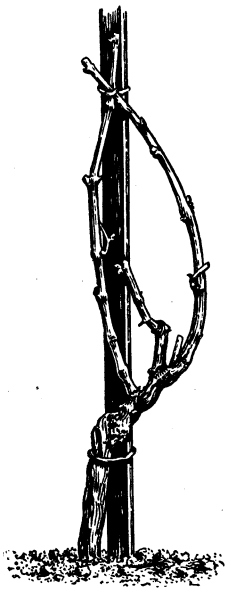

FIG. 29.—A pruned vine in its fifth year, showing the method of training by the cane system.

THE LONG OR CANE PRUNING SYSTEM.

The long or cane pruning system is also in general use in California. When vines are trained according to this system the fruit is borne on canes which are tied to a stake as shown in figure 29, the spurs which are left to grow from them producing canes for the following year. In pruning, the canes which fruited the previous year as well as the arms on which they grew are entirely removed, the canes produced from the spurs left the previous year furnishing the fruiting canes and spurs needed. In this manner the head of the vine is renewed from year to year, and as the plants grow older and stronger the fruiting capacity is increased by leaving more canes and spurs. Figure 13, *A*, shows a vine at the end of the second year; figure 30, at the end of the third year; and figure 29, at the end of the fifth year, pruned according to this system.

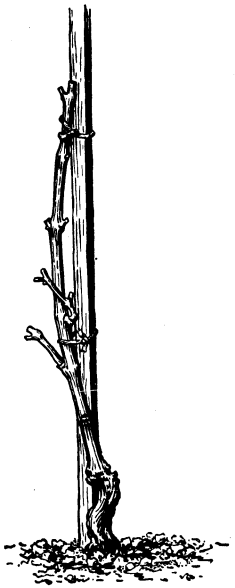

FIG. 30.—A pruned vine in its third year, showing the method of training by the cane system.

THE PRINCIPAL GRAPE REGIONS OF THE UNITED STATES.

There are three distinct viticultural regions in the United States which segregate themselves by the grape species grown in them.

The Vinifera region, in which Vinifera varieties are almost exclusively grown, is located almost entirely west of the Rocky Mountains, so much of it being in California that those not conversant with grape varieties erroneously call them California grapes. With few exceptions either the spur, stool, or short pruning system is used for the stockier growing varieties, and the long or cane pruning system is usually used for the longer growing varieties, but either system is often modified to suit individual varieties. Thus the spurs are sometimes left longer in the spur system, and either spurs and canes left longer or spurs cut on the laterals in the cane system.

Stakes only are used to give the vines the necessary support; this method allows the vineyard to be cultivated crosswise as well as lengthwise.[1] Vines trained on trellises are comparatively rare in California.

The more generally known Vinifera varieties grown in this district are the Alexandria, Alicante Bouschet, Aramon, Burger, Cabernet

[1] "See Grape, Rasin, and Wine Production in the United States," Yearbook, U. S. Dept. of Agriculture, for 1902.

Sauvignon, Calmette, Carignane, Chasselas de Fontainebleau, Cornichon, Emperor, Flame Tokay, Green Hungarian, Grenache, Malaga, Mission, Mondeuse, Mourestel, Pizzutella, Petit Syrah, Purple Damascus, Riesling, Semillon, Sauvignon Vert, Sultanina, Sylvaner, Valdepenas, and Zinfandel.

The Muscadine region of the South Atlantic and Gulf States includes the entire southeastern coastal plain extending from the Potomac to Florida, reaching well up into the Blue Ridge Mountains and along the Gulf coast to the Rio Grande River, spreading to the north along the Mississippi River into the great central plains to southeast Missouri and the Tennessee River. In this region improved varieties of the Rotundifolia and Munsoniana species are grown for various purposes, the better-known varieties of these being the Eden, Flowers, James, Mish, Scuppernong, and Thomas. The multiple cross-wire system or overhead arbor is almost exclusively used. As previously mentioned, these arbors are very similar to the overhead trellis or parrales system used in Spain with the Almerian varieties commonly seen in our markets packed in cork dust and called "Malaga" grapes.

The third or American native-grape region is the one in which improved varieties of the more northern native grape species and hybrids of them and the Vinifera species are grown. This region comprises all that part of the United States which lies east of the Rocky Mountains. Of late years a few plantings have also been made in parts of Oregon and Washington, but the industry is most extensive in the States west of the Hudson River and north of the Ohio River that border on the Great Lakes and in the more centrally located States of the Mississippi Valley. In this district the high-renewal, horizontal-arm spur, horizontal block, fan, Hudson horizontal, four-cane Kniffin, umbrella or two-cane Kniffin, Munson, overhead Caywood, and Chittenden systems are used, the localities in which they originated or are most common being stated in the description of the various systems. The varieties most extensively grown are the following: Agawam, America, Barry, Beacon, Berckmans, Brighton, Brilliant, Campbell, Carman, Catawba, Champion, Clinton, Concord, Cottage, Cynthiana, Daisy, Dawn, Delaware, Diamond, Diana, Duchess, Eaton, Elvicand, Elvira, Empire State, Fern, Gold Coin, Gaertner, Goethe, Headlight, Herbemont, Herbert, Iona, Isabella, Ives, Jaeger, Janesville, Jefferson, Lady, Laussel, Lenoir, Lindley, Lutie, Martha, Massasoit, Merrimac, Missouri Riesling, Moore, Muench, Nectar, Niagara, Noah, Norton, Olita, Perkins, Perry, Pocklington, Prentiss, Rommel, Salem, Triumph, Ulster, Vergennes, Victor, Washington, Wilder, Winchell, Wetumka, Woodruff, Worden, and Wyoming.

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Grape-Spraying Experiments in Michigan in 1909. (Bureau of Plant Industry Circular 65.) Price 5 cents.
The Grape Root-Worm, with Especial Reference to Investigations in the Erie Grape Belt from 1907 to 1909. (Bureau of Entomology Bulletin 89.) Price 20 cents.
Spraying Experiments against the Grape Leafhopper in the Lake Erie Valley in 1911. (Bureau of Entomology Bulletin 116, part 1.) Price 5 cents.